MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

ETN3046 – ANALOG AND DIGITAL COMMUNICATIONS

(All Section / Groups)

18 FEBRUARY 2023
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 7 pages (including the cover page) with 4 Questions only.

2. Attempt all of the **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Consider the signal $g(t)=10u(t)$, where $u(t)=\begin{cases}1, & t\geq 0\\ 0, & t<0\end{cases}$.

(i) Calculate the normalized power of $g(t)$. [3 marks]

(ii) Compute the normalized energy of $g(t)$. [3 marks]

(iii) Is $g(t)$ an energy signal or a power signal? Justify your answer. [3 marks]

(b) Obtain the trigonometric Fourier series of the periodic signal $f(t)$ shown in Figure Q1. [7 marks]

Note: The trigonometric Fourier series is given by:

$$f(t)=A_0+\sum_{n=1}^{\infty}A_n\cos n\omega_0 t+\sum_{n=1}^{\infty}B_n\sin n\omega_0 t$$

$$A_0=\frac{1}{T_0}\int_{T_0}f(t)\,dt,\ A_n=\frac{2}{T_0}\int_{T_0}f(t)\cos n\omega_0 t\,dt,\ n=1,2,3,\ldots$$

$$B_n=\frac{2}{T_0}\int_{T_0}f(t)\sin n\omega_0 t\,dt,\ n=1,2,3,\ldots,\ \omega_0=\frac{2\pi}{T_0}$$

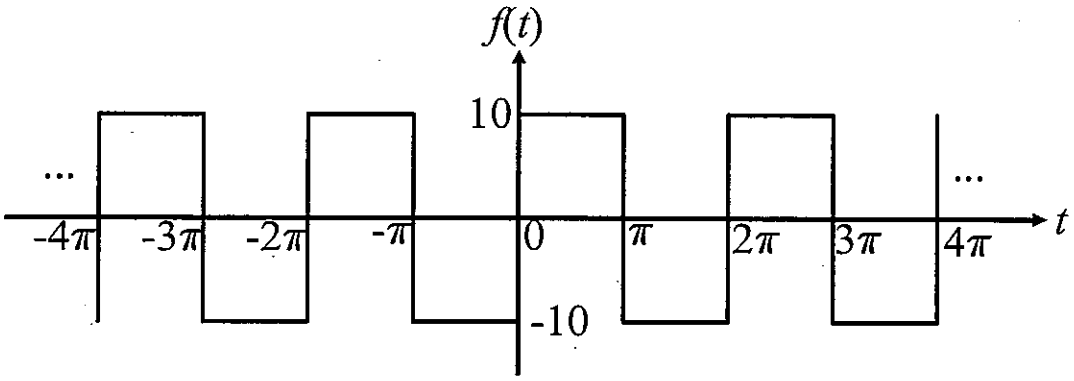

Figure Q1: Periodic signal $f(t)$.

(c) The Fourier transform of $x(t)$ is given by $X(f)=-4\pi j\tau^2 f\text{sinc}(f\tau)\text{sinc}(2f\tau)$. Determine the Fourier transform for the following signals:

(i) $r(t)=10x(2t)$ [3 marks]

(ii) $y(t)=5\dfrac{dx(t)}{dt}$ [3 marks]

(iii) $z(t)=x(t-1)$ [3 marks]

Continued .....

Question 2

(a) A 360 kHz bandwidth is to accommodate 12 radio stations simultaneously. Assume that the same modulation technique is used for all the stations and the maximum modulating frequency f_m is the same for all the 12 radio stations.

(i) Calculate the maximum modulating frequency for double sideband large carrier (DSB-LC) modulation scheme. [2.5 marks]

(ii) Repeat Question 2(a)(i) for double sideband suppressed carrier (DSB-SC) modulation scheme. [2.5 marks]

(iii) Explain in detail one advantage of DSB-SC over DSB-LC. [2 marks]

(iv) Explain in detail one advantage of single sideband (SSB) modulation over DSB-SC. [2 marks]

(b) Consider a double sideband large carrier (DSB-LC) transmission with a total power of 30 kW. Assume that the modulating signal $s_m(t) = A_m \cos(2\pi ft)$ and the modulation index is 0.7.

(i) Calculate the power transmitted at the carrier frequency. [2.5 marks]

(ii) Compute the power transmitted at the upper sideband. [2.5 marks]

(iii) Determine the power efficiency. [2 marks]

(iv) Suggest a method to demodulate the DSB-LC modulated signal. [1 mark]

(c) Explain in detail the functions of pre-emphasis and de-emphasis in a communication system using frequency modulation (FM) with the aids of diagrams (diagrams of the frequency responses of the pre-emphasis and de-emphasis, power spectral density at the input and output of pre-emphasis and de-emphasis). You can make your own assumption on the frequency responses and the input power spectral density of the pre-emphasis and de-emphasis. [8 marks]

Question 3

(a) Define the Nyquist sampling theorem. [2 marks]

(b) Figure Q3 shows the spectrum of a bandlimited analog information signal with maximum frequency f_m. Assume that the waveform is instantaneously sampled at f_s and $f_m = 30$ kHz.

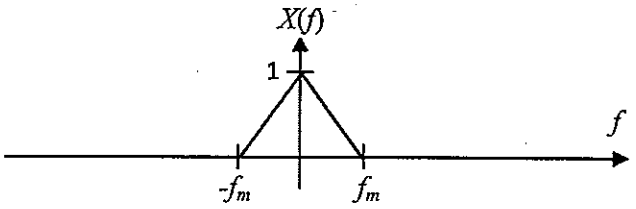

Figure Q3

(i) Calculate the maximum allowable sampling period that will ensure perfect signal reproduction. [3 marks]

(ii) Will aliasing occur if $f_s = 48$ kHz? Justify your answer. [2.5 marks]

(iii) Repeat Question 3(b)(i) for the case of flat-top sampling. [1.5 marks]

Continued .....

Question 3

(c) Consider a pulse code modulation (PCM) system with input $s(t) = 5\sin(600\pi t)$. The sampling rate of the PCM is twice the Nyquist rate. The sampled signal is then quantised using a uniform 16-level quantiser which covers a voltage range of (-5V, +5V).

(i) Compute the bit rate of the encoded signal. [5 marks]

(ii) Calculate the signal-to-quantisation noise ratio in dB at the output of the quantiser. [2 marks]

(iii) State one advantage of non-uniform quantisation over uniform quantisation. [2 marks]

(d) State two types of quantisation errors that are associated with the delta modulation and suggest a method to jointly address these issues. [4 marks]

(e) Define pulse shaping and describe the purpose of performing this process in telecommunications. [3 marks]

Question 4

(a) Explain two desirable properties of line coding. [4 marks]

(b) A digital communication system transmits data with a bit rate of 80Mbit/s using quadrature phase-shift keying (QPSK) over a wireless channel with bandwidth of 44 MHz. Assume that the overall equivalent transfer function is of the raised cosine type.

(i) Calculate the roll-off factor r. [3 marks]

(ii) Examine the possibility of a roll-off factor r be found so that a 90 Mbit/s data rate could be supported. [3 marks]

(iii) Determine the bandwidth saving in Hz if 16-QAM (quadrature amplitude modulation) is used to transmit data at a rate of 80 Mbit/s using the roll-off factor r obtained in Question 4(b)(i). [3 marks]

(iv) State one advantage and one disadvantage of raised cosine pulse shaping as compared to Nyquist pulse shaping. [3 marks]

(c) Explain in detail the differences between error detection codes and forward error control. [3 marks]

(d) A (7,4) Hamming code has the following generator matrix:

$$\mathbf{G} = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix}$$

Continued .....

Question 4

(d)

(i) Find the codeword produced by the message {1 0 1 1}. [3 marks]

(ii) Compute the syndrome for the received vector {0 0 0 0 0 0 1} and determine if an error has occurred. If it has, find the correct codeword. [3 marks]

Continued .....

APPENDIX

Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t)+bx_2(t) \Leftrightarrow aX_1(f)+bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{\lvert a \rvert} X\left(\frac{f}{a}\right)$
Time Shifting	$x(t-t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f-f_o)$
Time Convolution	$x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n}x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n}X(f)$
Time Integration	$\int_{-\infty}^{t} x(\tilde{t})d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f}+\frac{1}{2}X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^{f} X(\tilde{f})d\tilde{f}$

Continued .....

Useful Trigonometric Identities

$$\sin A \sin B = \frac{1}{2}\left[\cos(A-B) - \cos(A+B)\right]$$

$$\cos A \cos B = \frac{1}{2}\left[\cos(A+B) + \cos(A-B)\right]$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\sin\theta = \frac{1}{2j}\left[e^{j\theta} - e^{-j\theta}\right]$$

$$\cos\theta = \frac{1}{2}\left[e^{j\theta} + e^{-j\theta}\right]$$

Table of Bessel functions of the first kind

	$J_n(\beta)$							
n	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 1.0$	$\beta = 2.0$	$\beta = 3.0$	$\beta = 5.0$
0	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178
1	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328
2	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047
3		0.001	0.003	0.007	0.020	0.129	0.309	0.365
4				0.001	0.002	0.034	0.132	0.391
5						0.007	0.043	0.261
6						0.001	0.011	0.131
7							0.003	0.053
8								0.018
9								0.006
10								0.001

End of Paper